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UNATTENDED MODE OPERATION OF SPECIALIZED NDA SYSTEMS

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ABSTRACT

Nondestructive assay systems have been developed to allow data acquisition equipment to operate unattended in an automated mixed oxide facility, reducing inspector time in a facility and giving them time for other activities. Fewer inspector visits mean less impact on plant operators. Neutron detectors are located at key measurement points in the facility. Near each detector is located an electronics cabinet, which contains two JSR-11 shift registers, two COMPAQ Portable III computers, and a printer. The signal from the detector is split and sent to each shift register for redundancy and reliability. The software for unattended operation consists primarily of two programs, COLLECT and REVIEW. The COLLECT program runs on the computers in unattended operation; shift-register data are acquired each 60 s. The COLLECT program distinguishes between a normal background and a disconnected signal, between material moving near the detector and material in the detector, and whether the material in the detector is a sample or a californium normalization source. Depending on the type of assay, different data are stored on the hard disk. During an inspection, the inspector stops the current measurement campaign, examines the data from both computers briefly at the electronics cabinet, copies the campaign data to floppy disk, and starts another measurement campaign. These data are examined later in another location using the REVIEW program running on high performance microcomputers: a COMPAQ DeskPro 386/20 or equivalent. The REVIEW program uses graphical displays to enable the inspector to quickly search through the massive amounts of accumulated data to learn when samples were measured. Data from the desired measurements are then transferred to the International Atomic Energy Agency high-level neutron coincidence program for further analysis.

INTRODUCTION

Several neutron detectors connected to JSR-11 shift registers are located throughout the Plutonium Fuel Production Facility (PFPF). Material moves through the detectors by means of the robotics system while the process is operating. To limit inspector time at the facility, to increase safety by reducing radiation exposure to personnel, and to limit operator impact caused by these inspections, it was decided that the collection of data from the detectors would be done in unattended operation; data would be collected continuously, but the inspector would examine the data infrequently: about once a month. In practice, only the detectors located at the input and output ends of the plant operate for these longer periods. The other detectors located throughout the process line run in unattended operation for much shorter periods of time, typically overnight.

Unattended operation placed several constraints on the design of the hardware and software for the system. Because it would be difficult to redo unusual measurements, the system had to be highly reliable so that inspectors would be confident that the data they examined at the end of the month would reflect what actually happened. Several features were designed into the system to increase the redundancy and reliability, such as dual measurement systems, electronics cabinets using tamper detection International Atomic Energy Agency (IAEA) seals, continuous cable runs, and software self-diagnostics to detect interruptions in the data stream or unusual measurement conditions.

The software consists of two main programs. COLLECT controls the shift register to collect data continuously in the unattended mode. REVIEW is run about once a month to examine the large amounts of data collected. The REVIEW program also creates data files that can be input into the IAEA high-level neutron coincidence (HLNC) program to calculate grams of plutonium in the sample. Separating the software into two programs allows the inspector to spend minimal time in the radiation area collecting data. The data from the COLLECT program can be examined in a more comfortable environment with the REVIEW workstation computer. The overview of the software interaction is shown in Fig. 1.

DATA COLLECTION

The COLLECT program operates on the computers contained in the electronics cabinet located near each detector shown in Fig. 2. Each electronics cabinet contains two JSR-11 shift registers, two COMPAQ Portable III computers, an Epson LQ850 printer, a T-switch box to connect the computers to the printer, and a splitter box to route the signal from the detector to each of the JSR-11 shift registers. The two JSR-11 shift register/computer systems counting the same signal from the detector insure against data loss because of equipment failure.

The main function of COLLECT is to gather data continuously, but it has additional capabilities. The main menu of COLLECT is shown in Fig. 3. In addition to collecting data during a measurement campaign, this program allows the inspector to copy the data files to a floppy disk for transfer to the REVIEW program for further analysis, to print campaign summaries of previous data, to set parameters used in the collection analysis, and to delete old data from the hard disk. No

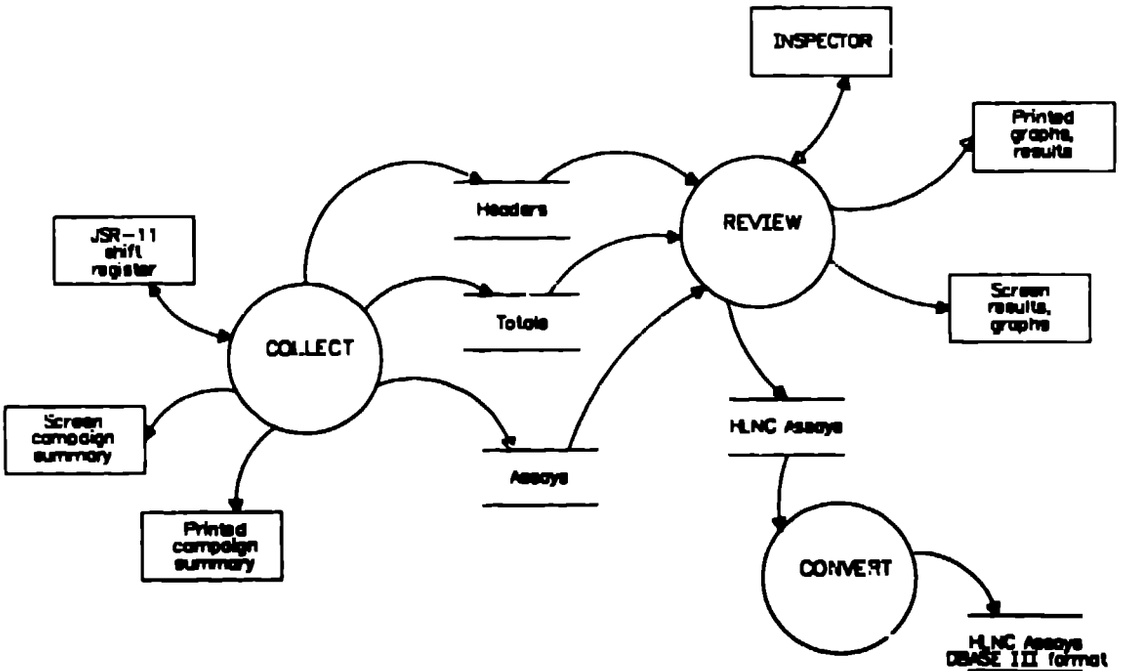

Fig. 1. PFPF data inputs and outputs.

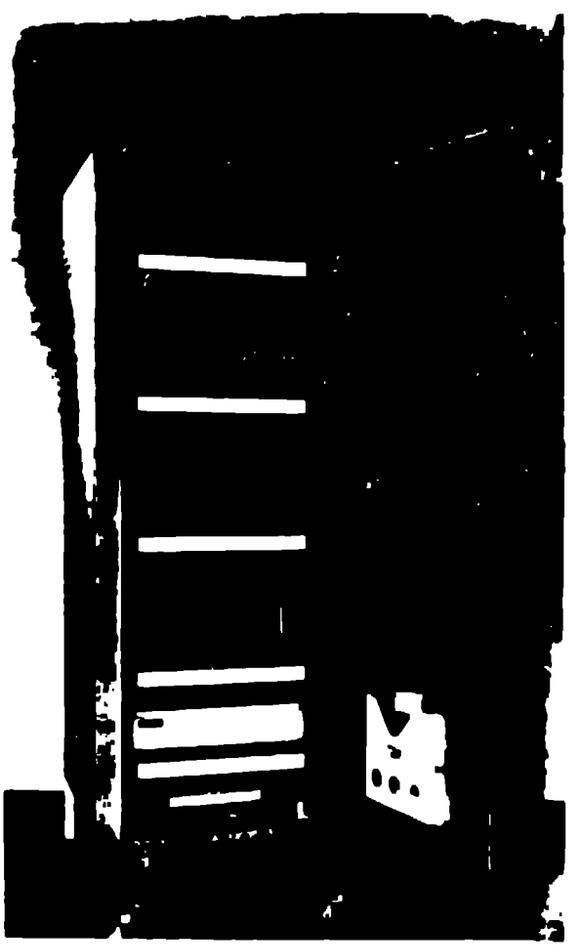

Fig. 2. Electronics cabinet located near the neutron detectors.

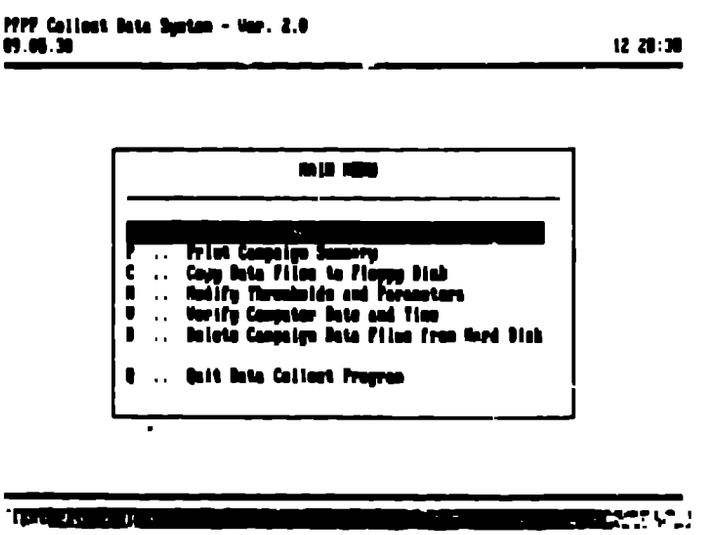

Fig. 3. COLLECT program Main Menu.

operator interaction is necessary during data collection. After each 60-s run, COLLECT reads data from the shift register and writes it to the computer hard disk. Data are formatted so that a month's output can be copied to a single floppy disk. Results are only printed when the inspector is present.

The inspector starts a measurement campaign by selecting the "Begin a New Measurement Campaign" option on both computers. After verifying proper functioning by watching the results for the first few minutes, the operator seals the electronics cabinet. During the unattended operation, data are acquired from the JSR-11 shift registers in 60-s intervals for periods up to 35 days. After each 60-s measurement, the COLLECT program analyzes the data to determine what type of run was just completed and updates the campaign summary, shown in Fig. 4. Several tests are performed:

- Background or assay
  If the reals rate is below the assay threshold rate, the run is a background and is examined to verify that its totals rate is within an expected range (a disconnected signal would produce a rate of 0). If the totals rate is lower than this range, this run is a low background and the field labeled "Low backgrounds" is incremented on the campaign summary. If the background falls within the expected range, the "Normal backgrounds" field is incremented. If the run is a background, only the totals data (measurement time and date, totals counts, count time, and status) are saved on the hard disk.

- Moving or stationary assay
  If the reals rate is above the assay threshold rate, the run is an assay and both assay and totals data are stored on the hard disk. Assay data comprise the measurement time and date, totals counts, reals + accidentals counts, count time, and a measurement status. As the sample is moving into the detector, the runs are above background, but only the measurements taken after the sample is placed into the counter are of interest. To determine when the sample is in the counter, the T²G test is performed. Only when the T²G test is satisfied is the sample assumed to be stationary in the counter.

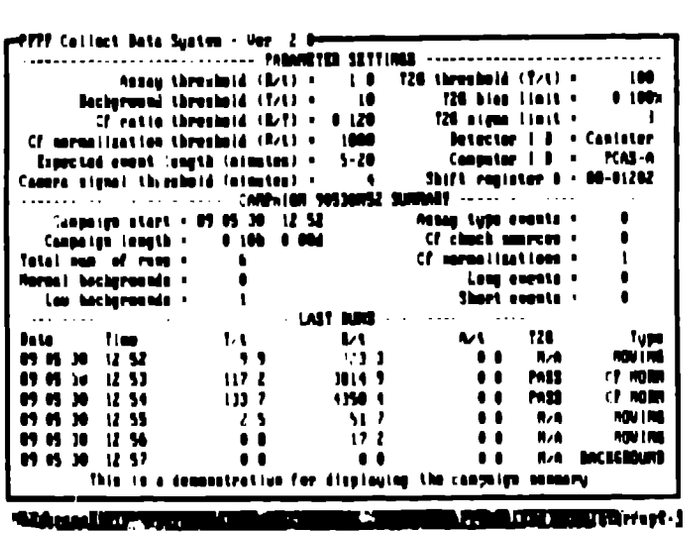

Fig. 4. COLLECT campaign summary.

- Sample or californium (Cf) assay
  If an assay passes the T²G test, the next run is analyzed to determine whether a sample or Cf source is being measured based on the reals/totals ratio. Cf assays have a higher ratio than a mixed oxide sample. If this run is a sample, the events field in the campaign summary will be incremented by one.

- Cf normalization source or Cf check source
  A normalization source with a known count rate is sealed in one of the canisters. If the Cf reals rate is high, then the run is from the normalization source, otherwise it is from the Cf check source. The appropriate field in the campaign summary is incremented by one.

At the end of the campaign (2-4 weeks) the inspector returns to the cabinet, inspects the seal, opens the cabinet, examines the system, and compares the campaign summaries on the two computers. The top section displays the parameters used in the analysis of the campaign just finished. The middle section includes the campaign start time, length, and the number of each type of run during this campaign. These numbers should be consistent on the two computer systems. The bottom portion of the campaign summary prints results of the most recent runs. After examining the summaries, the inspector terminates the current campaign, prints a hard copy of the summary, copies the data from this campaign onto a floppy disk for later analysis, and starts another campaign. The inspector repeats the procedure on the second computer and then re-seals the cabinet.

DATA REVIEW

The REVIEW program operates on the computers located in the workstation area of the PFPF. The Power Reactor & Nuclear Fuel Development Corporation (PNC) workstation consists of a COMPAQ 386/20 computer with a color VGA display screen, 60-Mbyte hard disk, and 1.44-Mbyte, 3-1/2 in. and 1.2-Mbyte, 5-1/4 in. floppy disks connected to an Epson LQ850 printer. The IAEA has a workstation with a similar capability. The primary functions of the REVIEW program are to store the raw count data from the COLLECT program in a database, to provide for rapid inspection and observation of these data, and to generate data files for input to the IAEA-HLNC code. Large amounts of data are produced by the unattended operation. A campaign of one month produces 43 000 raw data runs for each shift register/computer system. If each run were printed on a line, the results for one detector would cover 780 pages. The REVIEW program displays the data graphically so the inspector can quickly and easily examine it.

After the inspector has collected data from all the detector systems located throughout the PFPF, he or she uses the REVIEW program to examine the data. The REVIEW main menu is shown in Fig. 5. A typical REVIEW session would be started by first selecting the "New Data File Input" option from the main menu. The user is prompted through the steps to import the raw data on the floppy diskettes into the database on the hard disk system.

After all data have been imported, the Graph Rates option is selected to get a quick overview of the data from the campaign. The user has an option to graph only the totals rates, only the reals rates, or both the totals and reals rates. A typical totals and reals rates graph is shown in Fig. 6. The peaks on

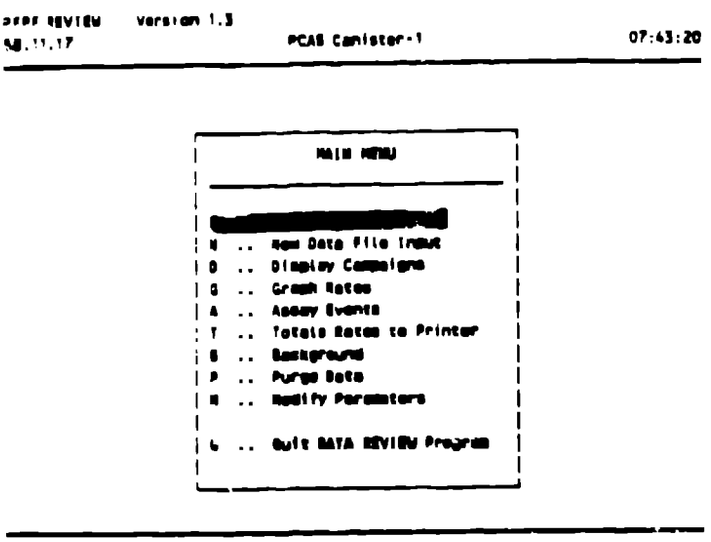

Fig. 5. REVIEW program Main Menu.

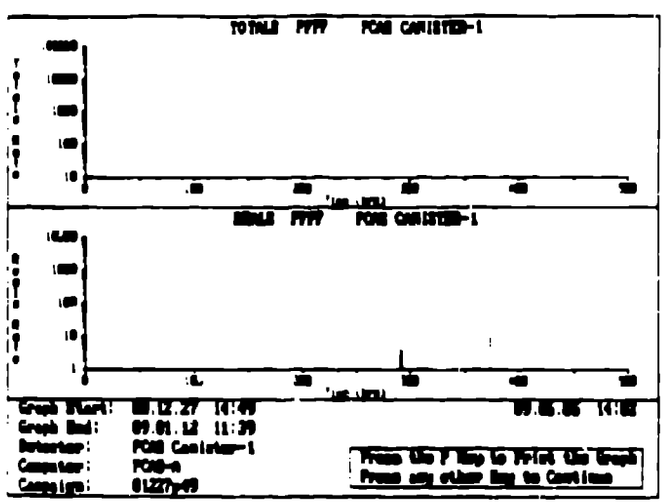

Fig. 6. REVIEW display showing totals vs time and reals vs time for a typical measurement campaign.

the bottom curve (reals rate) indicate when samples are in the counter; the totals rate curve indicates this time as well as the movement of the sample into and out of the detector. The interval can be changed to expand different areas of the graph by specifying a new starting date and time as well as the interval to be displayed. In this manner specific peaks can be fully examined. At any time, the user can print the graph.

The graph in Fig. 6 shows the activity in the canister counter in the feed storage area. In the room with the counter is a track on which canisters of material move from storage into the process area or back to storage from the process area. Also of interest in Fig. 6 is a peak on the totals graph that does not have a corresponding peak on the reals graph. This indicates when a canister was moving to the process area on the adjacent track.

Once the campaign data have been examined in their graphical form, the inspector typically selects the "Review Assay Events" option, in which the assay results for each individual campaign are displayed. The results are grouped into events with the type of counter (PCAS, FAAS, etc.) labeled and an indication of whether a particular run passed the PG test in the COLLECT analysis. A sample assay results screen is shown in Fig. 7. To transfer data to the IAEA-HLNC program, the inspector tags a set of runs and supplies an "Item ID" to it.

The REVIEW program has other options such as displaying which campaigns are available in the database, printing a selected set of totals runs, calculating background values, deleting data from the database, and changing parameters.

Once the inspector has used REVIEW to examine data from all the detectors, he or she can terminate the REVIEW session. Two short programs automatically transfer data sets tagged in REVIEW into the IAEA-HLNC program database. The HLNC program then analyzes the data to determine the plutonium content.

AUTHENTICATION OF DATA

In addition to the redundancy of the dual measurement systems and software analysis by COLLECT to detect unusual situations such as no signal, counters seeing signal for longer or shorter than the expected time, etc., several hardware features were designed to increase the authenticity of the data. The electronics cabinets containing the measurement equipment were chosen because of their tamper detection qualities. The cabinet door has an IAEA-tamper detection seal, which is examined during each inspector visit to the cabinet, and a new seal installed when the inspector leaves the cabinet. Continuous cables run from the electronics cabinet to the detector. These cable runs can be visually examined by the inspector. A security cover encloses the cable connectors at each detector. The security cover/seal combination prevents undetected access to the detector electronics and cable connections.

CONCLUSIONS

Unattended data collection is an attractive option to reduce inspector time at nuclear facilities, but places additional design

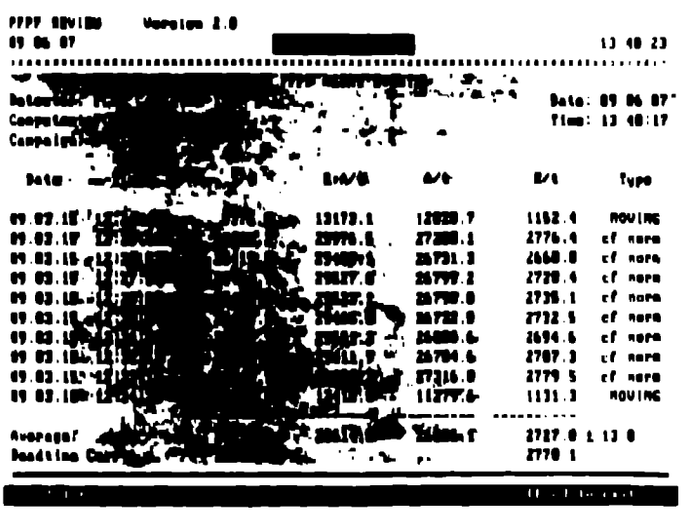

Fig. 7. REVIEW assay results summary

constraints on the system because data authentication is necessary. We found these additional constraints relatively easy to meet and the benefit of unattended operation to be worth the small extra effort. Collecting data in unattended operation has several advantages. The operator benefits from fewer interruptions because the inspector spends fewer days in the plant. The inspector gains because unattended data collection followed by a review procedure allows the examination of many days of data in a single day by using graphical displays to quickly identify the events of interest. Unattended data collection is particularly well suited to counters that must be monitored continuously because material could move through them at any time. An integral part of the unattended data collection scheme is a review program; it must be able to provide quick access to the large amounts of data collected in the inspection interval and display that data so that the important data are easily discernable.

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